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United States Department of Agriculture,

FORESTRY DIVISION.

(CIRCULAR NO. 6.)

INSTRUCTIONS FOR GROWING TREE SEEDLINGS.

The following circular has been prepared to accompany the customary distribution of tree seeds from this Department. It is hoped that the instructions will be followed by the recipients to the advantage of the plant material thus distributed.

J. M. RUSK,
Secretary.

SIR:

I have the honor to submit herewith a circular giving briefly such information in regard to raising forest tree seedlings from seed as appears essential for a proper performance of the manipulations involved. Failures are very often due to ignorance of the objects which are to be attained by following instructions.

While much must be left to the good judgment of the planter in the application of instructions, a knowledge of the principles underlying his practice will safely guide him. As far as the limited space of a circular permits these objects and principles have been elucidated.

It is desirable that these instructions be placed at least in the hands of those who receive tree seeds from the Department.

Respectfully,

B. E. FERNOW,
Chief of Forestry Division.

HONORABLE J. M. RUSK,
Secretary.

It may be set down as a rule, with few exceptions, that it is preferable and in the end more economical to grow seedlings in the seed-bed and nursery and transplant them, than to sow the seeds in permanent sites.

Success in growing seedlings is attained, first, by providing suitable conditions for the sprouting of the seed, and, secondly, by keeping up proper conditions for the development and growth of the seedling.

In order to know what the conditions are, the planter should have some knowledge of how the sprouting takes place and how the seedling develops and grows.

PRINCIPLES.

Sprouting.—Water, warmth and air are necessary to bring seeds to sprouting; darkness seems also to favor sprouting. To insure best results, the supply of heat and moisture must be moderate but even and constant. By keeping the earth-cover above the seed loose, sufficient air can penetrate to aid in dissolving the food materials in the seed, and the plantlet can also more easily find its way to the surface and the light. In contact with the moist warm soil, the outer shell or seed-coat takes up water and swells until it bursts; then the embryo, (germ or little plantlet), which lies imbedded in the seed, begins to grow, pushes downward into the ground its rootlet and upward to the light its stem and first leaves, called seed-leaves or cotyledons and plumulæ (which are often different in shape from the later leaves). The quicker the sprouting proceeds, the less danger of spoiling the seed, to which it is quite liable when lying in the ground too long.

Growth of the Seedling.—After the seed is sprouted and the germ nourished into life by the food stored up in the seed, the seedling must now provide its nourishment from outside. This it takes partly from the soil, partly from the air. From the air, carbonic gas is taken up directly by the leaves, in which it is changed into vegetable substance under the influence of light and heat. The food materials contained in the soil must first be dissolved so that the roots may be able to take them up; for this again water, heat and oxygen (air) are necessary. The food in watery solution is then conveyed by the roots through the stem to the leaves, which are the digesting apparatus (the stomach as it were) of the plant. Here, under the influence of light and heat, the water in which the food was dissolved is partly evaporated (transpired) and the food assimilated, used in forming vegetable substance, i. e. increasing the plant in size.

For the growth of the seedling, then, it is necessary that it should have at the roots a loose soil, rich in plant food, into which the rootlets can penetrate; *water*, warmth and air, in order to dissolve the plant food; and at the leaves *light*, warmth and air, in order to digest and transform the plant food into vegetable substance.

Transpiration from the leaves, which means giving up water to the air, is necessary to make plants grow, but excessive transpiration may kill the plants, and insufficient transpiration may keep the seedlings weak and undeveloped, or even kill them. Hot air and strong light make the leaves transpire greater quantities of water than when the air is cool or saturated with moisture and the plants are shaded. They also transpire more when the air is in motion than when it is quiet; a certain degree of circulation of air, however, is as necessary to plants as to human beings.

The main difficulty in growing seedlings is to regulate transpiration, to keep the water supply at the roots and the degree of light and heat at the top properly balanced.

Light and heat (or dry air) are the task-masters which make the leaves work, evaporating the water that is supplied at the roots. If the supply from the roots runs short, the plantlet soon exhausts itself in the endeavor of satisfying its task-masters and dries up; and even with ample supply of water the task required may be too much, and the delicate machinery of the plantlet may not be able to work fast enough and may break down under too great a strain. On the other hand, if too much water be supplied at the roots, they are liable (with most plants) to rot. The supply of moisture at the roots must, therefore, be kept even and moderate, while the rate of transpiration may be regulated above and kept in proportion by the use of varions contrivances.

Seed.—In regard to the seed, the planter should have at least the following knowledge:

Not all trees produce seed every year, and only few trees, if any, produce all perfect seed. The number of seeds in one hundred which will germinate, (percentage of germination), even in a fresh sample, varies with the kind and the year.

Some seeds lose their power of germination (sprouting) soon after ripening and must be sown at once. Such are willows, poplars, birches, elms, soft maples, etc. Others may be kept, with proper precautions, for one season (oak, chestnut, alder, ash, maple, linden, fir); a few can be kept alive for many years (spruce, larch, and pine). The heavier and larger seeds produce the best plants.

The different kinds swell and sprout more or less readily according to the structure of the seed-coat. Some will swell in a few hours, others will take several days, and in some seeds swelling occurs—under ordinary circumstances—only after months and years, like black and honey locust, acacias, red bud, juniper, Kentucky coffee tree. These are called "refractory" and are said to "lie over," that is, they do not sprout readily but may lie in the ground for one or more seasons without sprouting. Some seeds become "refractory" by being kept, and their coat being allowed to become dry they lose the faculty of absorbing water readily and the swelling may be delayed a year or more (they lie over.) This is the case with ash, larch, fir, Douglas spruce, and others. Such seeds can be made to sprout more readily by soaking them in water (hot or cold) and by various other methods.

To preserve seeds in good condition the main point is to keep them cool and prevent them from drying out by mixing them with sand or in any other way.

PRACTICE.

Soil and Site.—The best soil for a seed-bed is a well drained loamy sand. This is suitable for all kinds of trees and should be specially prepared if not found naturally; it may be so varied that for small and light seed there is added more sand, for heavy and large seed more loam. Manure is unnecessary, but whatever manure, compost, or sod-ashes, is used to enrich the soil must be thoroughly rotted and mixed in. The soil must be worked into thoroughly mellow condition to a depth of 10 or 15 inches, free from stones, lumps, weeds, like the most carefully prepared garden bed.

For a small quantity of seedlings make boxes 4 to 6 inches deep, of a size convenient to handle when filled with soil, bore three or four half-inch holes in bottom for drainage and fill with loamy sand.

The choice of a proper site for seed-bed often makes all the difference in the amount of after-care necessary and in the success. A well sheltered level spot within reach of water, with an eastern or southeastern aspect, protected against the scorching sun and drying winds by a wind-break or wall, is most suitable.

The dangers to the seed if left in the seed-bed through the winter make sowing in the spring the rule, except with those seeds which cannot be kept or are apt to spoil by keeping, and which should if possible be sown soon after ripening. Elm, soft maple, birch, are therefore sown in June; alder, hard maple, linden, fir, etc., are best sown in fall; oak, chestnut, beech, and other nuts which require much care in keeping are also often sown in fall; while conifers, which ripen late, are mostly kept till spring. Fall sowings sprout earlier in spring, and the seedlings are therefore more liable to danger from late spring frosts. Even temperature being most favorable for sprouting, the choice of time in spring varies according to the locality and the season, when the weather becomes settled. Middle of April to May is probably a mean or average time.

Quantity of Seed.—The quantity of seed to be used on a given area, or the room needed for a given quantity of seed, depends on the size of the seed as well as on its quality. Consideration should also be given to the rapidity of development of the seedlings and the length of time they are to remain in the seed-bed. Deciduous trees require more room the first year than conifers. The number of seeds per pound allows a fair estimate of the comparative room required, making allowance for quality. (Poor seed and of kinds which produce much immature seed, like elm and larch, must be sown more thickly.) The number of lineal feet of drill per ounce of seed varying of course according to quality of seed, may be roughly stated as follows: Ash, maple, honey locust, cherry, and similar seeds 20 to 25 feet drill per ounce; catalpa, elm, alder, birch, etc., 40 to 45 feet; pines (very variable in size) and spruces from 30 to 60 feet, mostly the latter; firs with a small per cent. of germinating seed may be sown as thick as 1 ounce to 10 feet of drill, and larch, 1 ounce to 25 or 30 feet. Black locust, with a high per cent. of germination and vigorous development the first year, not less than 40 feet; one pound of chestnuts, acorns, hickory nuts, will require 10 to 12 feet drill; 1 pound of walnuts may require 5 feet.

Method of Sowing.—Sowing in drills is preferable to broadcast sowing, because it can be done more even and the plants can be more easily cared for by weeding, loosening the soil, mulching, thinning out, as well as more readily moved for transplanting.

A distance between the drills of 4 inches is sufficient for conifer seedlings remaining one or two years in the seed-bed; deciduous tree seeds, which develop rapidly during the first year, require a distance between the drills of 9 to 12 inches.

As to width of drill, one seeded so as to produce a single row of plants is preferable to a broader drill with many plants; although more plants are grown on the same space in the latter case, they are as a rule not as strong and vigorously developed.

Make drills across the bed by pressing the soil down with the edge of a lath or board of proper width, or for deeper drills, with a stick or hoe or other suitable tool.

In sowing, a piece of cardboard bent at right angle or a trough made of two light strips of wood nailed lengthwise at right angle will do service in evenly distributing the seed.

The depth of the drill, or what is the same the depth to which the seed is to be covered, depends on the size of the seed.

The object of covering the seed, besides excluding the light and as a protection against the birds, etc., is to prevent the drying out of the seed and later of the plant germ as it pushes up. The covering must be thin enough to allow the air to penetrate to the seed, and the germ to push through to the light. Better too little than too much cover. *Too much cover is the death of many seeds*, and at least results in retarding germination, smaller number and weaker plants.

The following are the maximum depths to which the seeds mentioned may be covered with loose soil, and which may serve as guide for other seeds:

Oak, chestnuts 1¼ to 2½ inches; maple ½ to ¾ of an inch; black locust (an exception to the rule) will stand and produce best results with a cover of 2 inches; alder ⅕ to ⅓ of an inch; spruce, Scotch pine, and larch ⅓ to ½ of an inch; Austrian pine ¾ of an inch; birch and elm as thin as possible (a cover of ½ an inch prevents germination entirely.)

The drills may be covered to advantage with other material than the soil of the seed-bed, such as garden mold mixed with sand, sod-ashes, sawdust, which keep loose and moist and afford additional plant food. The covering material is filled into the drills, heaped full and then pressed down gently (firmed,) to bring seed and soil into close contact, which helps to supply the moisture.

Fall sowings may be covered more heavily. A cover of sphagnum moss, powdered for small seeds, makes an excellent cover, being light and retaining moisture. But care must be taken to make this cover not too thick or to replace it with soil when the seed has germinated, in order to avoid the spindling growth to which the plantlet would be forced through the thick cover.

If the soil is in proper condition, fresh or moist, no watering is required, but if water seems necessary it is better to apply it before sowing.

After-care.—During the period of sprouting, which may last from two to four weeks in the average, the only care necessary is to prevent the soil from drying out. Especially after the seed has begun to swell the supply of moisture must be even and constant. Small seeds naturally dry out more easily than large, and therefore require closer attention. The moisture supply is kept even by watering, or better by covering with mulch, which prevents evaporation, or with lath screens, described further on.

Watering should be avoided as long as possible, but must be resorted to if the soil becomes dry and then must be kept up until rainy weather occurs, since, by watering, the soil becomes packed and liable to dry out more rapidly than before. The watering is best done evenings with a very fine rose. Large seeds require less water, small seeds generally most; *except conifers*, which can get along with very little. In fact, the greatest care must be taken with these not to give too much water, as the young plants damp off very easily. With the use of shallow boxes the watering can hardly be avoided. Placing the boxes in moist ground will reduce the need of watering.

Covering the ground, or shading, to prevent evaporation is better than watering. This covering or mulching is done right after sowing, and consists of a thin layer of sphagnum moss or cut straw; the shading is done by lath screens or otherwise. If moss or straw is used it is necessary to carefully watch when the seedlings appear and remove the cover at once, to avoid spindling growth of the young plants, and replace it by a side cover of brush stuck alongside the drills. This cover also furnishes protection against too much cooling off during the night.

But better and more convenient than all these means of protection are the lath screens; a contrivance which facilitates the protection of the seed-bed and the seedlings afterwards so much that nobody should attempt to grow seedlings without them. These consist of a frame of two parallel sticks, or better, pieces of board 5 to 6 inches high and laths 1¼ inches apart nailed across. These frames or screens are best made the width of the seed-bed, say 3 feet and any length that is needed, not over 4 feet for convenient handling. They can be placed directly on the seed-bed, or better, on short poles driven into the ground or on legs, one at each corner, raising the frames 6 to 8 inches above the bed.

The danger of losing the seedlings is greatest after they have appeared above ground and for three to four weeks afterwards. It is then that greatest attention is needed in regulating moisture supplies.

The lath screen does excellent service in regulating the moisture of the soil and the transpiration of the plant, by protecting them from the direct rays of the sun, heat and wind, and keeping the air below the screen cooler and moister. The use of these screens is more or less important in the earlier stages of the life of all seedlings, and with conifers and a few specially tender kinds they are best used the entire first season. They are then gradually raised on poles to 2 or 2½ feet above ground, and at last entirely removed, when the wood is matured.

During rainy or cloudy days and nights the screens are best removed or raised and occasional airing during the hotter parts of the day is needed, especially with conifers. Most deciduous trees soon grow beyond the need of this protection, but yet are benefited by having some side protection, such as a wind-break or wall at some distance or a hedge will furnish.

Watering of seedlings may sometimes become necessary in dry weather.

Cultivation.—The soil must be kept free from weeds and loose, to absorb moisture and prevent evaporation. Hilling it up along the seedling row is advantageous in keeping them moist, and a mulching between the rows of moss, litter, or even stones, helps to keep down weeds and protects the soil against drying. The pulling of weeds is done in wet weather or after watering and repeated as often as necessary; the last weeding should be done in September. The loosening of the ground not deeper than 1 or 2 inches is best done in dry weather when the soil will crumble, and should not be continued after August, to avoid winter killing of a late, unmatured growth.

The first loosening of beds sown in the fall is best done in spring as soon as all danger of frost is passed. The spring beds are cultivated when the soil under the influence of continued rain followed by heat has packed together; under otherwise favorable conditions cultivation does not become necessary again more than once or twice during the season.

Protection against frost may become necessary either in the fall or oftener in the spring, even of the second year. The damage done is due to a rapid change of temperature, and, especially, the rapid thawing of frozen parts under the influence of the sun after a cold night, also by the dry cold winds of winter.

To guard against the late frosts of spring sow late in spring; cover fall sowings after the first strong winter frost with mulch to prevent an early start in spring, or place lath screens over the seed-bed, whenever the sky is clear and frost expected. If this has been neglected with plants they may still be saved by watering before sunrise, which retards the thawing; or at least shading against the early morning sun.

The different kinds are liable to frost in a different degree. Oak, beech, fir, chestnut, locust, ash and spruce are more sensitive to late spring frosts than maple, elm, linden; others, like most pines, alder, birch, do not suffer at all or rarely. The time of budding has also some influence with regard to liability to frost; the trees which bud early naturally being more exposed to the danger than those which like oak, ash, and locust bud late.

Thinning.—Lastly, if the seedlings stand too close, as may happen even with the best care in distributing the seed, and almost always if the seedlings are to remain two years in the seed-bed, it is desirable to thin out the rows, by pulling out from the middle of the drill the weakest plants. This is done either the first summer or in the spring of the next year.

Seedling Nursery.—As a rule, and especially a rule for such climates as that of our western plains and prairies, most seedlings should not be transplanted into permanent sites until two or three years old. They should first be transplanted into plant beds and by proper care fitted for the hardships which they meet in the permanent site. In fact, as has been stated at the outset, that planting is preferable and more economical in the end, than sowing in the permanent site, so it may be stated that using "schooled" or transplanted plants from the nursery is safer and therefore more economical in the end, than planting directly from the seed-bed. The care of plants in the nursery will form the subject of a separate paper.